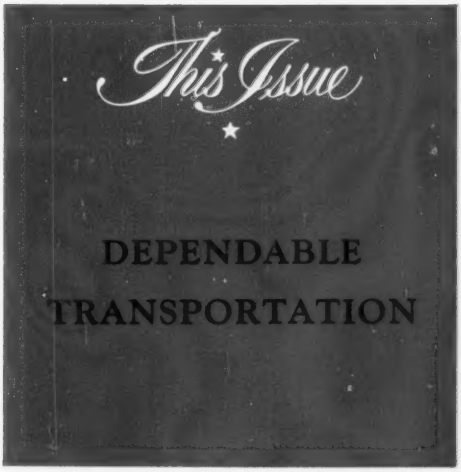
Volume 46 SEPTEMBER-OCTOBER, 1960 *Number 9*

Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants



PUBLISHED BY
TEXACO INC.
TEXACO PETROLEUM PRODUCTS

Now–enjoy greater driving ease, quiet and comfort–with TEXACO MARFAK CHASSIS LUBRICATION

Texaco Marfak is no ordinary grease—but a superior chassis lubricant. It protects and cushions sensitive bearing surfaces. You will enjoy that *cushiony* feeling for 1000 miles or more—and your car will last longer, stay younger.

Your car will ride smoother, handle easier and ride quieter. On the roughest roads, under constant shocks, in all weather, Texaco Marfak won't squeeze out, wash out or dry up. It stays put—to protect your car, to insure your greater riding comfort.

Enjoy that cushiony feeling—after your car chassis is lubricated with Texaco Marfak—at your Texaco Dealer, the best friend your car has ever had.

MARFAK
Lubrication
TEXACO INC.

TEXACO

Buy the Best—buy

TEXACO

LUBRICATION

A TECHNICAL PUBLICATION DEVOTED TO THE SELECTION AND USE OF LUBRICANTS

Published by

Texaco Inc., 135 East 42nd Street, New York 17, N. Y.

Copyright 1960 by Texaco Inc.

Copyright under International Copyright Convention. All Rights Reserved under Pan-American Copyright Convention.

A. C. Long, Chairman of the Board of Directors; J. W. Foley, President; C. B. Barrett, Oscar John Dorwin, M. J. Epley, Jr., T. A. Mangelsdorf, J. H. Rambin, Jr., T. C. Twyman, Senior Vice Presidents; A. W. Baucum, C. N. Brooks, Harvey Cash, J. B. Christian, W. G. Copeland, S. T. Crossland, F. M. Dawson, L. B. Derby, C. H. Dodson, W. P. Gee, J. W. Green, Ben Halsell, L. C. Kemp, Jr., Kerryn King, I. G. Morgan, J. H. Pipkin, Vice Presidents; Wallace E. Avery, Secretary; R. G. Rankin, Comptroller; G. W. Orton, Treasurer.

Vol. XLVI September-October, 1960 No. 9

Change of Address: In reporting change of address kindly give both old and new addresses.

"The contents of 'LUBRICATION' are copyrighted and cannot be reprinted by other publications without written approval and then only provided the article is quoted exactly and credit given to TEXACO INC."

DEPENDABLE TRANSPORTATION

DURING its sixty-year history both the design and the operating conditions of the American automobile have changed radically with corresponding tremendous effects on the qualities required in its fuel and lubricants. For example, early owners never attempted to start and use their cars during the winter; the modern driver expects his infinitely more complex car to start instantly and operate dependably regardless of season and weather.

The early cars were largely used only for extensive summer tours of considerable length wherein their engines operated steadily under ideally warm conditions. Oppositely, the modern car is most often used for frequent but short "convenience" trips to the station, school or shopping center wherein its engine and engine *oil* never get warm enough for best efficiency. Surveys have shown that *two thirds of today's automobile trips are less than eight miles long*. The public generally does not realize that this modern cold-engine stop-and-start driving is the severest kind of *heavy duty operation* which has most adverse effects on car reliability. Owners who quickly realize this fact and provide their cars with the modern *heavy duty* type fuels, lubricants and other protective maintenance that are so necessary to preserve dependability do themselves a great favor.

ENGINE LUBRICATION

Without its engine a car is a dead and practically useless obstruction. Other faults in the car are mainly annoyances, but engine or engine accessory failures are crucial and vital. Thus in most instances car reliability really means *engine* reliability. The most important contributor to engine reliability is its motor oil which includes not only the properties or "quality" of the new oil, but also how long and how well those properties are *maintained* during its use in the engine. It is unreasonable to place a high quality motor oil in an engine and then forget it; as will be seen, many subsequent and expensive difficulties are directly traceable to such forgetfulness.

The following highly-condensed paragraphs associate the engine's several complex requirements with the several properties of a high quality oil that are required to meet them. A modern oil must be very versatile!

Viscosity, Viscosity Index, Multigrading

In American passenger car engines, an oil pump is used to draw oil from the four or five quart supply in the crankcase pan and force it under pressure to the several bearings on the crankshaft, connecting rods, camshaft, valve rocker arms, timing chain or gears and hydraulic valve lifters. Piston skirts, piston rings, wrist pins, cylinder walls and camshaft lobes are normally lubricated by oil spray escaping from the connecting rods or other pressure-lubricated bearings. To prevent frictional wear or seizure and immediate destruction,

all of these rubbing parts must be separated from each other at all times with an unbroken film of oil, regardless of the load, speed and temperature imposed on the film. The ability of an oil to form and maintain a film is determined by its *viscosity*, "body", "thickness" or "weight" and is its most important single property. If other conditions are held constant and only the viscosity of an oil is increased:

(1) the thickness and load-carrying ability of the film *increases*

(2) the internal friction, power absorption and operating temperature of the film *increases*

(3) the tendency to leak through a small hole (and therefore the consumption) *decreases*

(4) the spraying ability *decreases*

To add to these contradictory complexities, the viscosity of any oil increases as its temperature is decreased; oppositely, it thins out as its temperature goes up. At low temperatures a motor oil must be thin enough to permit the engine to start and to lubricate itself, yet thick enough at high operating temperatures to maintain an unbroken load-carrying film. Thus the selection of one specific optimum viscosity is an impossibility and even a viscosity band must be a compromise. Consequently, all American car manufacturers utilize the SAE* Motor Oil Viscosity Grade Classification system which prescribes the maximum and minimum viscosities at temperatures of 0°F. or 210°F. for each of the seven current-standard SAE Viscosity Grade numbers of 5W, 10W, 20W, 20, 30, 40 and 50. The "W" grades are particularly suited for *winter* use. The 5W grade is primarily intended for "arctic" or continued sub-zero temperatures and is rarely available even in the northernmost portions of the continental United States. It should be emphasized that the SAE viscosity grade system applies only to oil viscosity *and has no relationship whatsoever to any of the many other properties required in a high quality motor oil.*

In 1939 the SAE suggested five standard Fahrenheit temperatures (less than minus 10; minus 10, plus 10, plus 32 and above 90) for use in conjunction with the foregoing viscosity grade system. There has been little progress in adopting this simplification since the manufacturers of the 1960 cars quote eleven different limiting temperatures for four viscosity grades. Actually a modern, well designed and constructed engine is nowhere near as critical of oil viscosity as this wide variety of viscosity-temperature recommendations might infer. In fact many engines have been operated throughout the year on the SAE 10W grade without adverse effect other than somewhat increased oil consumption. The solitary bit of agreement in this matter is the *universal recommendation by all manufacturers for all temperatures of the relatively new 10W-30 multigrade oil.*

*Society of Automotive Engineers

Viscosity Index ("VI") is one arbitrary numerical method of indicating the sensitivity of an oil's viscosity to temperature changes; an oil with a high viscosity index number is less affected by temperature, or in other words it has a wider useable temperature range. Thus if the viscosity index of an oil is high enough, it can meet the viscosity requirements of two different SAE grades. Such a *multigrade* (not "multi viscosity") oil is usually labelled with both of the limiting grades together with any intermediate grades. As examples, the 20W-20 viscosity grade has been common for many years while the new 10W-30 grade meets the viscosity requirements for both the SAE 10W (winter) and SAE 30 (summer) grades, and can also be used for the intermediate 20W and 20 grades.

Oxidation Resistance

All motor oils will "oxidize", or slowly burn, when exposed to the oxygen in the air, though some types are more susceptible (or less resistant) than others. Oil oxidation is speeded up either or both by increasing the oil temperature, or by contact with such common oxidation catalysts as metallic copper, iron, lead and zinc. At temperatures up to the flash point of the oil, oxidation is incomplete, hence such partial oxidation products as carbon, oil varnish or lacquer and organic acids are formed, and these also may act as oxidation catalysts to accelerate an already vicious circle of events. Finally, the smaller the quantity of oil and the longer it is subjected to these conditions, the more rapidly oxidation will occur. Some of the results of excessive oil oxidation are clogged oil pump screens with engine seizure, stuck piston rings with high oil consumption, stuck hydraulic valve lifters with reduced power and expensive camshaft damage, pistons varnished firmly to their cylinder bores, stoppage of vital oil passages and the rapid corrosive removal of cadmium and lead in certain bearing alloys. During recent years all these evils have been largely prevented by the combination of (1) modern "heavy duty" oils (API Service Classification MS, DG or DM) which contain anti-oxidant additives (2) regular oil drain periods of reasonable length and (3) the fact that during the prevalent stop-and-start short trip driving, and in spite of small crankcase capacities, oil temperatures rarely get high enough to encourage any appreciable *oil* oxidation.

Foam Resistance

All mineral base oils (and in fact most liquids of appreciable viscosity) have an inherent tendency to pick up air bubbles when agitated and thereby form air foam. However, a few small bubbles

on the oil dipstick, or a whitish appearance of drained oil should not be construed as foam. Since foam is a compressible mixture, it is a poor lubricant which has little load carrying ability and therefore causes bearing failures and inoperative hydraulic valve lifters. As its contained air heats up and expands, the foam forces itself out crankcase breathers and oil fill pipes with consequent messiness and loss of oil. Finally the remaining oil is subjected to increased oxidation because of the presence of so much intimately-mixed warm air. Such mechanical conditions in the engine as (1) too high an oil level, (2) an air leak into the oil pump intake, (3) a "floating" oil pump intake stuck above oil level, or (4) excessive spray from an open oil pump pressure regulator valve, can all induce foam. Fortunately, the best "heavy duty" motor oils are treated to enormously increase their ability to resist foam formation.

Detergency, Dispersancy

A thoroughly warm engine will completely burn practically all of its gasoline to form harmless steam and hot carbon dioxide gas which blow out the exhaust system without leaving residues. However cold engines, which are the natural result of stop-and-start low-speed short-trip driving, are woefully inefficient. They *completely* burn only some gasoline with consequent poor fuel economy. Worse yet they only *partially* burn the remainder of the gasoline with the result that large quantities of liquid water, fuel soot or carbon, sticky fuel varnishes, corrosive fuel acids, and unburned liquid fuel are formed. None of these is desirable, yet all strongly tend to accumulate within the engine where they cause combustion chamber deposits with knocking or preignition, shorted spark plugs, clogged and stuck piston rings, high oil consumption, rusting and excessive wear of engine parts, low-temperature crankcase sludge, and oil pump screen stoppage with engine seizure and destruction. Oil filters are only partially effective and uneconomic for removing these undesirables, but are highly recommended otherwise. The only certain, and also the least expensive, method of removing them from the engine is to drain them with the used crankcase oil. This means that the oil should have considerable *detergency* or cleansing power to remove existing deposits, combined with large *dispersancy* or carrying power to prevent settling and the formation of new deposits. Mineral oils have some natural or inherent detergent-dispersant ability but the refiner must greatly reinforce these properties in true heavy duty oils (API Service Classification MS or higher) by the addition of complex chemical detergent-dispersant additives. *All American car manufacturers now recommend an oil of* MS *or higher service classification for "heavy duty" use.*

Contrary to popular belief, most engine "wear" is actually *rusting* caused by condensation and chemical attack of liquid water and fuel acids, when engine jacket temperature and crankcase ventilation capacity are too low to vaporize and discharge these corrosive liquids. It has been proven repeatedly that at engine jacket temperatures of 100°F or less, engine wear is at least fifteen times greater than at warm operating temperatures above 140°F. The old practice of "warming up" engines by idling them uselessly at the curb is now recognized as the surest and quickest way of wearing them out. Straight mineral oils have but little rust prevention ability. Fortunately however, certain dispersant-detergent additives are doubly effective in preventing rust, since they not only physically displace water from metals, but also combine with and neutralize acids.

Extreme Pressure Properties

To obtain maximum power at high speeds, modern engines are equipped with large and heavy valves which require ultra-strong springs to close them quickly. Unfortunately, at the low engine speeds that are characteristic of stop-and-start driving, camshaft lobes and the contacting lifter surfaces may be overloaded and quickly wear out. Though this is largely a matter of engine design and correct metallurgy, it has been found that a certain type of extreme pressure additive will greatly enhance the wear resistance of these important and expensive parts.

Combustion Chamber Deposits

These also are largely the result of stop-and-go part-throttle driving where combustion temperatures are not high enough to burn oil and gasoline completely. As previously mentioned, these deposits increase the "octane appetite" of an engine and can cause both noisy detonation and destructive (but dangerously silent) preignition! In many cases they can be effectively reduced or even eliminated by either a few miles of turnpike-speed driving or merely by a half dozen full-throttle accelerations. Since a fully distilled motor oil burns away more cleanly after its lubrication job is done, some car manufacturers privately recommend this type, and publicly recommend the habitual use of a 10W-30 oil which is most likely to contain such a base oil.

OIL DRAIN PERIODS

From the foregoing it should be obvious that to obtain maximum satisfaction, dependability and engine life, even the finest of ultra-heavy duty crankcase oils must be drained regularly and always before: (1) its engine-protective additives are

exhausted, and (2) its capacity to remove and retain fuel contaminants is exceeded. The color of a heavy duty detergent oil is not a reliable indication of its suitability for further use since it will frequently (and should) get black within the first five minutes of use. The cost of a single, reliable, and meaningful automotive oil analysis exceeds by many times the value of the oil. Though it is manifestly impossible for anyone to predict how fast an oil of unknown quality will be contaminated in an engine of unknown mechanical condition, subjected to unknown operating conditions, the car owner is presently faced with a bewildering array of oil drain recommendations ranging from weekly to several thousand miles, or even never. As a very simple, understandable and economic solution to the oil drain problem the American Petroleum Institute recommends the following:

In winter — every 30 days
In summer — every 60 days
But never to exceed 2000 miles.

ENGINE ACCESSORY CARE

The two bearings in the generator require not more than four drops of an SAE 20W motor oil every 1000 miles. The central shaft of the distributor usually requires periodic grease or oil lubrication to prevent wear and consequent rough low-speed operation. The multilobed cam on the distributor shaft should be coated thinly with a rust preventive grease to prevent rapid wear of the fiber point rubbing blocks, consequent retarding of ignition timing and loss of power. To prevent rusting and sticking, the distributor's centrifugal advance mechanism should receive not more than two drops every 1000 miles of a rust-preventive heavy duty SAE 20W oil; on the other hand, too much oil at this point may cause the formation of short-circuiting carbon whiskers on the distributor points.

Corrosion on battery terminals should be cleaned off and prevented by coating them with chassis grease.

ENGINE COOLING SYSTEM

While a hot engine is an efficient one, all engine metals lose strength rapidly with increasing temperature. Consequently, a cooling system must be used to keep engine temperatures within reasonable limits — neither too hot nor too cool. With but one exception, all 1960 American cars use the conventional "indirect" liquid cooling system in which water (or antifreeze solution) coolant is pumped through channels in the engine block and cylinder heads to absorb heat, cooled by dissipating its heat to air passing through the radiator, then recirculated to the engine. A thermostatic valve or "thermostat", usually in conjunction with a radiator bypass, is used to bring coolant temperature rapidly up to a minimum temperature of about 160°F., thereby improving engine warmup performance and economy while reducing engine wear. Thermostats with 180°F. or higher opening temperatures are obtainable and are useful for increasing heater performance, but can be used only with high-boiling glycol type antifreeze. To further increase their heat rejection capacities, most cooling systems are now pressurized as much as 15 psi above atmospheric pressure by means of a spring loaded pressure relief valve in the radiator pressure cap. One obvious disadvantage of the pressurized system is its greater tendency towards leakage. An additional "vacuum relief" valve in the cap prevents atmospheric pressure from collapsing the radiator hoses and tanks as the engine cools down. Thus such a system is by no means "sealed" since it repeatedly takes in air and discharges low-boiling antifreeze components during normal operation.

Unless the cooling system receives essential minimum maintenance, it can cause or promote engine overheating and seizure, valve burning, detonation or knocking, poor fuel economy, stuck valve lifters, sludge deposits, loss of antifreeze, and high engine wear with consequent high oil consumption and smoking. A properly maintained cooling system should never require flushing.

Water is by far the best liquid coolant because of its extremely high heat absorption capacity. However, its useful temperature range is severely limited by its high freezing point (32°F.) and relatively low boiling point (212°F.). Furthermore, either alone or in conjunction with dissolved minerals, gases and acids, water rusts or corrodes the several metals composing the cooling system. Iron rust is visible and gives helpful warning; on the other hand, corrosion of the lead-tin solder and very thin copper in the radiator core will proceed without visible warning until leaks suddenly appear. Reputable antifreezes contain corrosion inhibitors, however, these are exhausted either by neutralizing unsuitable water or subsequent contamination. Therefore, for summer use the best coolant is either deionized or distilled water containing a reputable commercial corrosion inhibitor, or (for some air-conditioned cars) a fresh, weak (20°F. freezing point) solution of the same type of water with a good glycol type antifreeze which contains effective inhibitors. For winter use, a fresh but suitably stronger (and lower freezing point) glycol solution is recommended.

The bearings of modern water pumps are usually permanently lubricated, however a good glycol antifreeze will lubricate and prevent the carbon water pump seal from squealing.

TRANSMISSION & CLUTCH

All transmissions are torque converters in the sense that they convert the engine's low-torque high-speed power into the high-torque low-speed power required by the driving wheels. The "conventional", "manual", or "stick" transmissions are purely mechanical assemblages of gears, and usually are lubricated with either a fairly viscous (SAE 80 or 90) multipurpose gear oil or a heavy duty type motor oil of SAE 30 or 40 viscosity grade. The conventional clutch which must always be used with a manual transmission is usually of the single plate dry type with permanently lubricated pilot bearing, but requiring periodic lubrication of the throwout bearing and pedal linkage.

Oil level should be checked every 1000 miles; some manufacturers recommend draining, flushing and replacement of the oil at regular intervals ranging between ten and twenty thousand miles. Overdrives are semi-automatic speed-increasing devices used optionally but only with manual transmissions, and are similarly lubricated.

Today the truly "conventional" transmission is the very popular fully automatic type, a very complex but extremely convenient and dependable assemblage of: (1) a hydraulic combination torque converter and fluid coupling, (2) transmission oil pumps, (3) one or more hydraulically-shifted planetary gear sets with their wet clutches, "brake" bands and servo mechanisms, and (4) an automatic control system or "brain" containing a speed-sensitive governor, possibly a load-sensing or throttle modulator device, and a series of intricate finely-finished automatic hydraulic valves which must be kept free from rust and varnish. As should be suspected, these remarkable automatics all absolutely require the equally remarkable and complex Automatic Transmission Fluid Type A or Type A, Suffix A which were developed along with the automatics and which are one of their most essential single parts. Because of heavy demands that are placed on it, most car manufacturers recommend that this fluid (actually a special oil blend containing numerous special additives) be drained and replaced at regular intervals ranging between 10,000 and 26,000 miles or at least every year.

The term *transaxle* usually indicates the combination of an automatic transmission with the driving axle. Though the two elements are separately lubricated at the present, their eventual complete combination will require another highly specialized lubricant.

DRIVE SHAFT AND UNIVERSAL JOINTS

These elements transmit the fairly high transmission output torque to the driving (usually the rear) axle. As the axle moves up and down with road irregularities or changes in car load, the drive shaft must also change its length; some drive shafts incorporate a sliding spline joint which may be lubricated automatically from the transmission but usually requires separate grease lubrication at intervals between 1000 and 24,000 miles if mysterious clunks, grunts or clicking noises are to be avoided. Depending upon the particular design, the universal joints themselves now usually require disassembly and handpacking with grease about every 25,000 miles.

DIFFERENTIAL

The differential case (the bulge in the middle of the driving axle) contains the engine-driven hypoid pinion gear and wheel-driving ring gear which increase transmission torque to the high wheel torque required to start and propel the car. To permit the different wheel speeds required to turn a corner, a differential gear set is interposed between the ring gear and the wheel axles. Since a "free" differential of this conventional sort will allow useless slippage of a wheel on ice, some differentials now contain automatic self-locking or non-slip mechanisms. The entire mechanism is lubricated with a specific type of multipurpose hypoid gear lubricant. Some manufacturers recommend drainage, flushing and refill as often as 10,000 miles or yearly: others prescribe lubricant change only when the differential is replaced.

WHEEL BEARINGS

Each front wheel rotates on a pair of ball or roller bearings which should be cleansed and dried with surgical care, inspected closely, machine or handpacked with a minimum quantity of a proven wheel bearing grease and adjusted snugly but not tightly. Manufacturers' relubrication intervals vary widely between 10,000 miles or yearly up to 25,000 miles or "when wheels are removed for other services" such as brake relining.

Most rear wheel bearings are of the roller type and are factory-lubricated "for life" or automatically lubricated with oil from the differential. Only one manufacturer now recommends deliberate removal and repacking at each 25,000 miles.

BRAKES

All *service* or "foot" brakes are now of the internal protected type and are hydraulically operated. Foot pressure on the brake pedal is applied mechanically to the piston in the master cylinder which greatly increases and transmits equal hydraulic pressures to the four or six "slave" or wheel cylinders within the wheel brake drums. Under

this pressure the pistons in the wheel cylinders move outward only a few thousandths of an inch and force the frictionally-faced brake shoes outward against the drums. With present designs and materials, the most satisfactory *and in fact the only brake fluid that should be used* is a complex heavy duty type meeting SAE specification 70R1. Such a fluid should lubricate the rubber piston cups without swelling or shrinking them, prevent rusting or corrosion of master and wheel cylinders with consequent leakage and even seizure, remain entirely fluid at very low temperatures, and yet have a sufficiently high boiling point to avoid the dangerous formation of vapor bubbles within the system. Though the present type of brake fluid and mineral oil are not miscible, any contamination of the former with the latter can be quite damaging to the many rubber parts in the brake system and must be avoided. While shoe pivots, retracting springs and backing plate guide surfaces are occasionally coated sparsely with a thin coating of grease to remove rubbing squeaks, any grease or brake fluid whatsoever on brake lining is so damaging that complete replacement of the lining is usually required.

In passenger cars, power brakes (or more properly power *assist* brakes) are provided by linking the piston of a large vacuum-actuated power cylinder to the hydraulic brake master cylinder. By means of a clever valving system, engine intake manifold vacuum is applied to one side of the power piston to assist the driver in proportion to the physical pressure that he himself exerts on the brake pedal. Since the vacuum power cylinder admits moist fresh air on every brake application, its steel cylinder can be protected from rusting, piston seizure and brake lockage by adding an ounce of SAE 10W *heavy duty* motor oil through its small air cleaner initially and every 10,000 miles thereafter.

The *parking*, "hand", or "emergency" brake system is wholly mechanical and utilizes either a brake drum on the transmission end of the propeller shaft, or cable-and-lever actuation of the rear wheel service brake shoes. In the latter type, the driver should habitually stop his vehicle with his service brakes *before* applying the parking brake, otherwise air may be drawn into the wheel cylinders to cause "spongy" useless brakes.

SUSPENSION SYSTEM

To allow all wheels to move up and down over road irregularities and to permit the front wheels to be steered, the chassis (frame) and body are "suspended" above the wheels by various systems of levers and springs.

The front wheels of all 1960 cars are *independently suspended*, i.e. each wheel has its own spring and parallel "wishbone" linkages, consequently its vertical movements are practically independent. The word "practically" is used because the two front wheel suspension systems are frequently interconnected with a sway bar which with spring and shock absorber reactions through the chassis removes some independence. Front wheels are "sprung" by inserting either large coil springs or torsion bars or pressurized rubber bellows in the suspension system between the wheels and chassis. To permit steering, each front wheel suspension incorporates either the time honored *kingpin* or two of the new *ball joints*, each of which combines the functions of three bearings in the kingpin system.

With but one "independent" exception, 1960 model rear wheels are tied togeher with a conventional rear axle housing. The large majority of these axles are sprung with conventional multi-leaf springs, the remainder with coil springs or air suspensions and the requisite radius rods. Through extended application of rubber bushings, flat spring inserts, impregnated "lubricated for life" plastic inserts and ball joints, the car manufacturers are trying with varied success to reduce or eliminate the number of chassis bearings that require periodic relubrication. Rubber bushings occasionally squeak and need a few drops of a special rubber lubricant — mineral oils will destroy ordinary rubbers and must be avoided. Springs containing inserts should never be lubricated since the inserts are usually destroyed thereby; on the contrary when squeaking begins, the spring leaves should be separated or disassembled to permit complete replacement of the inserts. Some early ball joints developed squawking, grunting or crunching noises which were caused either by initial failure to get lubricant between the rubbing surfaces or by inadequate lubricant retention. Most of these were cured by properly relieving the load on, and rotating the joint during lubrication; exceptionally stubborn cases were cured by using a grease containing a solid lubricant.

Shock absorbers are now "lubricated for life" and can not be serviced or overhauled; when they fail they must be replaced entirely.

POWER STEERING

Like power brakes, power steering assists the driver by supplementing, but not replacing the manual system. With the engine running, only a slight effort on the steering wheel opens a valve and applies oil pressure to the appropriate side of a power piston which moves the road wheels in the direction desired. As soon as the driver stops

turning his wheel the valve closes and the road wheels are held in the position he has indicated. The latest power steering systems are *integral* and *coaxial* with the steering column which means that they are self-contained except for the engine-driven high-pressure pump, its oil reservoir, and two connecting hoses. Only three or four pints of Automatic Transmission Fluid Type A or Suffix A are required to fill the system and there are no current instructions to ever drain or replace it. Reservoir fluid level check and replenishment every 1000 miles is advisable however, since too low a level permits the pump to draw in air with consequent spongy, erratic and inadequate steering action.

GASOLINE ECONOMY

No subject is more hotly debated with fewer facts! Because it is impossible to refill a car tank to an identical level twice in succession, no sensible driver should quote economies that are based on a single or even several tankfuls. Since their heat contents are practically identical, the *potential* powers and economies of gasolines are much alike. Finally however, the efficiency with which the potential chemical energy of any gasoline is converted into mechanical energy is so greatly influenced by so many car and driving conditions that the small but real differences among gasolines may be entirely submerged, and particularly if the differences are of unusual long-term significance like the reduction of engine wear. Any of the following fifty factors which decrease engine power output or increase the power required from it will decrease gasoline economy: (1) lower compression pressure; (2) spark plugs misfiring; (3) valves sticking; (4) richer carburetor mixture; (5) brakes dragging or driver "riding" the pedal; (6) ignition setting retarded; (7) distributor centrifugal or vacuum advance mechanisms sticking in retard position; (8) detonation; (9) uncontrolled combustion ("preignition", often noiseless); (10) new or recently-overhauled "stiff" engine; (11) sticking carburetor float; (12) leaking carburetor float valve; (13) automatic choke sticking near closed position; (14) manifold heat control valve sticking in cold-carburetor position; (15) air cleaner dirty or over-filled; (16) radiator thermostat sticking open; (17) higher viscosity grade of motor oil; (18) lower tire pressures; (19) certain tire tread patterns and rubbers; (20) use of winter "snow" tires or chains; (21) smaller than standard diameter tires; (22) excessive fuel pump pressure; (23) automatic transmission clutches or bands slipping; (24) power steering; (25) automatic transmission not in "country" or driving range; (26) conventional clutch slipping; (27) heavier transmission and axle lubricants; (28) bad front wheel alignment; (29) higher driving speed; (30) unsteady maintenance of speed; (31) throttle "jiggling"; (32) "jack rabbit" full-throttle accelerations; (33) shorter trips; (34) increased number of stops, red traffic lights and warmups; heavier traffic; (35) increased car load (more passengers or baggage); (36) increase in velocity or directness of a head wind; (37) snow, wet, muddy, icy, rough or dirt roads; (38) more, steeper or longer hills; (39) hauling a trailer; (40) weaving in traffic; (41) more use of brakes; (42) windows or ventilators open, especially at higher speeds; (43) use of lights, radio, air conditioner, windshield wipers or inside fans; (44) lower outside air temperature; (45) lower barometric pressure; (46) increase in altitude; (47) more use of lower high-ratio transmission gears; (48) little or no coasting; (49) parking car in sun; (50) car tilted when refilling gasoline tank or spillage.

A few concrete examples should be of interest. The following test results obtained on a popular "big three" car equipped with automatic transmission, power steering, and brakes illustrate the effect of speed on level road and full throttle fuel economies. Since they are highly accurate chassis dynamometer determinations, with all other variables controlled as closely as possible, these results are ideal maximums not obtainable on the open road.

Steady Speed, MPH	Economy, MPG	
	Level Road	Full Throttle
30	23.3	3.5
40	20.3	3.5
50	17.8	3.7
60	15.6	4.3
70	14.5	5.8

From the foregoing it is evident that (1) level road economy drops steadily as speed increases, (2) economy is drastically reduced by merely opening the throttle and this is especially true at low city speeds.

Figure 1, illustrating the very destructive effect of short-trip driving on gasoline economy, was obtained during a calendar year on a particular car used for all types of driving, but with only one driver, fuel and oil. Depending on the distance covered each day, the economy of this car varied from as little as 3 to as much as 16.6 miles per gallon. Particularly notice the extreme slope and sensitivity of the curve up to an average of forty miles per day. Short trips waste fuel!

The long-term effect on economy of keeping engine wear to a very minimum is illustrated by the following remarkably consistent average annual figures on the same car:

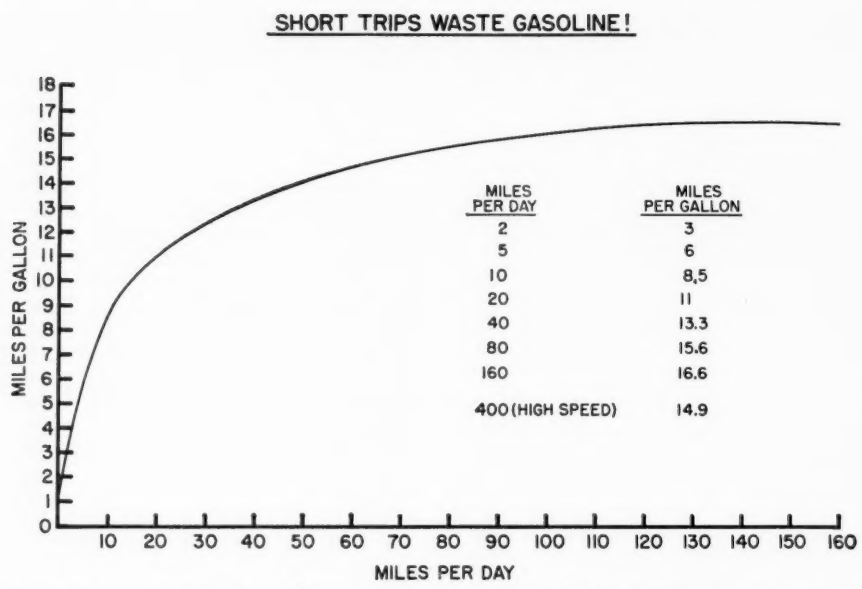


Figure 1 — The influence of daily mileage driven on gasoline economy. Typical points on the curve are shown in the table. Note the effect on economy of the high speed required to accumulate 400 miles per day.

Calendar Year	Annual Average Fuel Economy mpg
1956	13.1
1957	12.7
1958	13.1
1959	13.06

The following average figures obtained on eighteen initially-new cars driven steadily at 70 mph for 25,000 miles each will illustrate the real but conservative effects of an unusual gasoline additive which effectively reduces engine friction, rust, wear and deposits.

	Top & Second Piston Ring Wear, mgs	Total Exhaust Valve Replacements	Octane Requirement Increase	Fleet Fuel Economy mpg
Base gasoline	613	29	4.2	16.6
Gasoline with additive	365	8	3.1	16.8

Though not easily detected in a multicylinder engine, and especially at higher speeds, one or more misbehaving spark plugs will greatly reduce power, economy and smoothness as the following results from accurate chassis dynamometer tests on a popular V-8 engined car at 50 miles per hour will demonstrate.

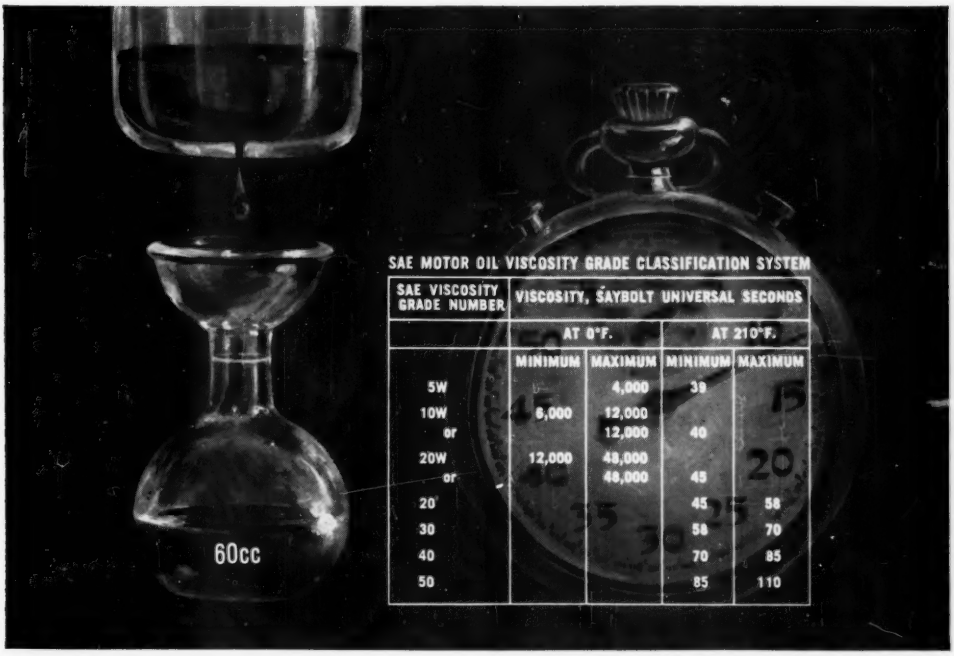
Spark Plug Condition	Level-Road fuel economy, miles/gal	Full-Throttle Power, Pounds of rear wheel traction
All firing	15.7	760
#1 out	13.9	640
#1 & #8 out	12.3	515
#1, #3, #8 out	10.3	390

Just one misfiring spark plug in the above car wastes as much gasoline money in only 430 miles as the cost of a new plug!

SUMMARY

The modern automobile is a highly complex device which is most often used under conditions quite different from its designers' intentions. However the damaging consequences of this forced misoperation can be prevented if the car owner first realizes their effects and then provides his car with *heavy duty type fuels and lubricants* and a reasonable amount of other preventive maintenance. Since the average car owner does not usually have the inclination, leisure, specialized tools, manual skill, and detailed mechanical and electrical knowledge required to accomplish these requirements himself, he must choose others to perform these services for him. A logical procedure is to first choose a single reputable brand of heavy duty type fuel and lubricants, then select a responsible local source which supplies them together with conscientious preventive maintenance.

Printed in U. S. A. by
Sallev & Collins, Inc.
305 East 45th Street
New York 17, N. Y.



SAE MOTOR OIL VISCOSITY GRADE CLASSIFICATION SYSTEM

SAE VISCOSITY GRADE NUMBER	VISCOSITY, SAYBOLT UNIVERSAL SECONDS			
	AT 0°F.		AT 210°F.	
	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM
5W		4,000	38	
10W	6,000	12,000		
or		12,000	40	
20W	12,000	48,000		
or		48,000	45	
20			45	58
30			58	70
40			70	85
50			85	110

Viscosity is measured by the time required for 60cc of oil in the Saybolt Viscosimeter Tube to flow through a standard opening, at a given temperature.

What viscosity really means

Viscosity is a liquid's *resistance to flow*. It varies among different liquids, and increases to some extent as temperature drops.

In the United States, the viscosity of oils is usually determined with a Saybolt Universal Viscosimeter. It simply measures the time in seconds required for a given quantity of oil to drain through a standard hole at some fixed temperature. The SAE Motor Oil Viscosity Grade Classification System (see chart above) uses these viscosity seconds to specify the viscosities of its SAE 5W, 10W, 20W, 20, 30, 40 and 50 motor oil grades. The first three "W" grades are especially suited for winter use.

The viscosity of your motor oil is very important. When you start your engine at a subzero temperature, a heavy, slow-flowing oil takes much too long to reach engine parts and permits more wear than thousands of miles of driving. However, a light, fast-flowing winter oil does not have enough viscosity to prevent wear at high summer temperatures. Thus, with ordinary oils, it is necessary to change grades seasonally.

Havoline Special 10W-30 Motor Oil is the wisest choice for any car owner because it magically combines the fast-flowing property of the Winter SAE 10W grade with the high temperature, wear-preventing quality of the Summer SAE 30 grade. It's the ideal, all-temperature oil. Use it *in all seasons*.

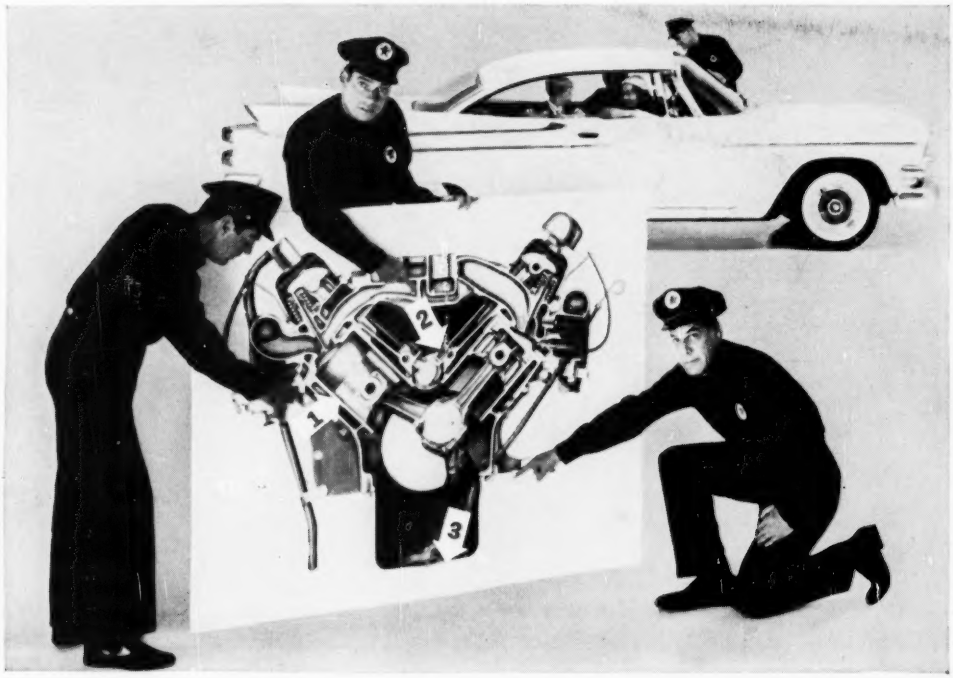
In addition, Texaco's special refining and exclusive additives in Havoline Special 10W-30 prevent the harmful sludge deposits and varnish that are so prevalent with ordinary oils in today's stop-and-go driving.

The few extra pennies for this finest of motor oils is your best insurance against engine damage and repair bills. See your Texaco Dealer for a change to Havoline Special 10W-30 ...and change it *regularly*.

TEXACO

Buy the best . . . buy TEXACO

TUNE IN: TEXACO HUNTLEY-BRINKLEY REPORT / MONDAY THROUGH FRIDAY / NBC-TV



New All-Temperature Havoline gives maximum protection against wear

HERE'S WHY:

1. You get maximum protection against cold-start wear! Unlike ordinary motor oil, all-temperature Havoline Special 10W-30 stays free-flowing even in dead of winter. Coats surfaces with a rustproof, scuff-proof film the instant you flick the starter. You start faster. You get maximum protection against *hot-running wear!* All-temperature Havoline's tough body resists extremes of engine heat and pressure.

2. You get greater gasoline mileage, pep and power. There's always a protective film between moving parts, such as all-important cams and valve lifters.

3. You get maximum protection against sludge and deposits. *This oil cleans as it lubricates!* Prevents sludge and deposits so engine runs smoother, quieter, more reliably. Change your oil every 1,000 miles and make sure it's all-temperature Havoline Special 10W-30 . . . *the best motor oil your money can buy!*

TEXACO INC. • • • DIVISION OFFICES

ATLANTA, GA.....864 W. Peachtree St., N.W.
BOSTON..830 Boylston St., Brookline 46, Mass.
BUFFALO 5, N. Y......P.O. Box 368
BUTTE, MONT......220 North Alaska Street
CHICAGO 4, ILL......332 So. Michigan Avenue
DALLAS 1, TEX......1512 Commerce Street
DENVER 3, COLO......1570 Grant Street
HOUSTON 2, TEX......P. O. Box 2332
INDIANAPOLIS 1, IND., 3521 E. Michigan Street
LOS ANGELES 5, CAL......3350 Wilshire Blvd.
MINNEAPOLIS 3, MINN......1730 Clifton Place
NEW ORLEANS 16, LA......1501 Canal Street
NEW YORK 17, N. Y......205 East 42nd Street
NORFOLK 2, VA......3300 E. Princess Anne Rd.
SEATTLE 1, WASH......1511 Third Avenue

Texaco Petroleum Products are manufactured and distributed in Canada by Texaco Canada Limited.